



UNIVERSITÀ DEGLI STUDI DI NAPOLI  
FEDERICO II

itee<sub>PhD</sub>  
information technology  
electrical engineering



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NA

Matteo Ciotola

# Deep learning for data fusion in remote sensing and beyond

Tutor: Giuseppe Scarpa

Cycle: XXXVI

Year: Second

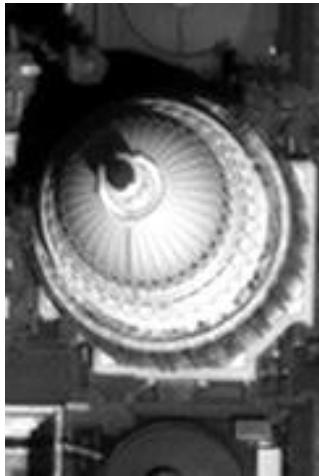
# My background

- MSc in Automation Engineering – Università degli Studi di Napoli Federico II
- Research group: GRIP
- PhD start date: 11/1/2020
- Scholarship type: UniNA

# Research field of interest

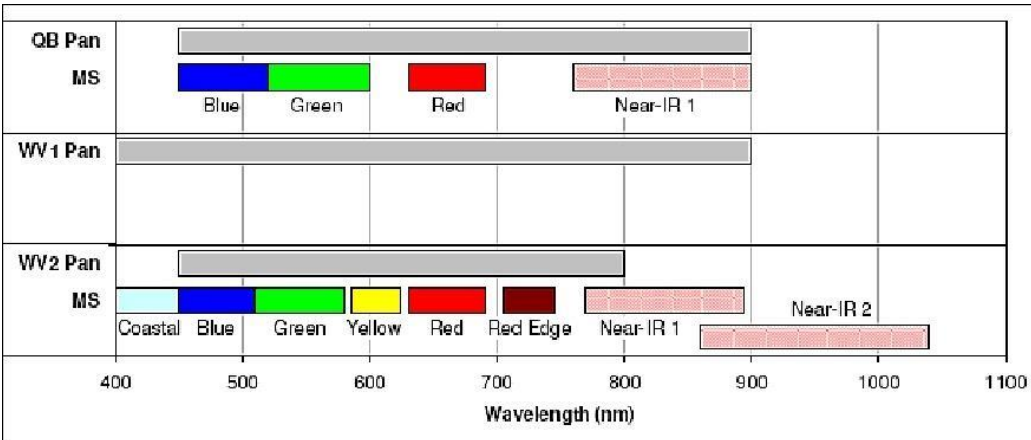


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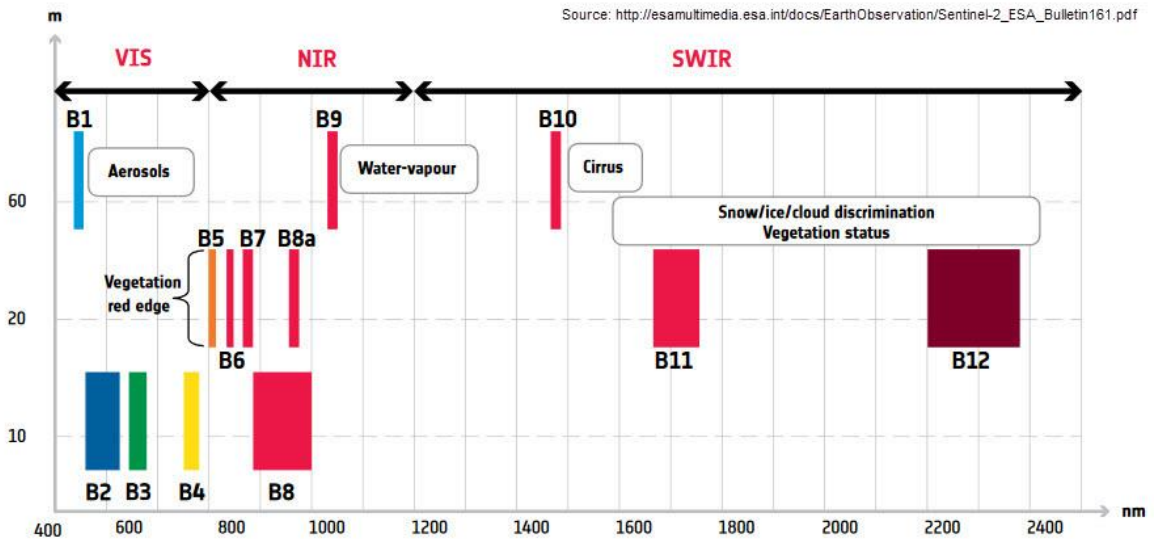
- Objective: development of Pansharpening and Super-Resolution algorithms in a deep-learning and data fusion framework
- Importance of super-resolved data: a high-definition multispectral data improve the accuracy of soil classification and may be used in several application such as land monitoring, agricultural, climate change analysis, defense
- Data fusion thanks to the exploit of some bands with a high spatial and low spectral definitions and other bands with low spatial and high spectral definitions

# Pansharpening



# Super-Resolution

Source: [http://esamultimedia.esa.int/docs/EarthObservation/Sentinel-2\\_ESA\\_Bulletin161.pdf](http://esamultimedia.esa.int/docs/EarthObservation/Sentinel-2_ESA_Bulletin161.pdf)

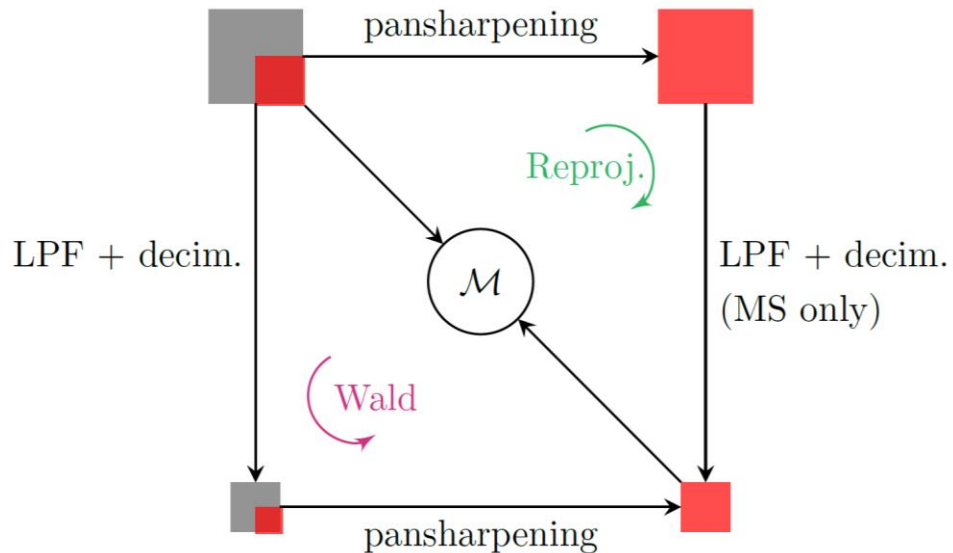


# Summary of study activities

- **PhD School:** “DeepLearn 2022 Summer School – 6<sup>th</sup> International Gran Canaria School on Deep Learning”, **Lecturers:** Prof. Phillip Isola, Prof. Irwin King, Prof. Louis-Philippe Morency, Prof. Johan Suykens, Prof. A. Murat Tekalp; The school gave an overview of the state-of-the-art deep and reinforcement learning techniques applied on several topics, such as Image Restoration, Computer Vision, Graphs, DeepFake, etc.
- **PhD courses:**
  1. “Scientific Programming and Visualization with Python”, **Lecturer:** Prof. Alessio Botta; The course gave the basic knowledge about the scientific programming language Python and its most famous libraries: NumPy, SciPy and Matplotlib.
  2. “Introduction to Deep Learning”, **Lecturers:** Prof. Giovanni Poggi, Eng. Diego Gagnaniello; The course gave fundamental concepts and theoretical tools on machine learning, artificial neural networks and deep learning. Some lectures focused on practical tools, through coding sessions with Keras library and Python language.
- **Conference:** “IEEE International Geoscience and Remote Sensing Symposium - IGARSS 2022” Virtual Conference, July 17-22, 2022

# Research activity: Overview

- Pansharpening and super-resolution are both two techniques of remote sensing images enhancement. These techniques are used for several applications, such as defence, agricultural, environmental defence;
- The goal is a definition of a framework to improve the resolution of multispectral bands
- The main difficulty is the lack of ground truth with which evaluate the goodness of algorithms



# Research activity during the Second Year

- Pansharpening:
  - Study of State-of-Art of Pansharpening, especially regarding of new trend of unsupervised training frameworks
  - Study on inter- and intra-bands misalignment problem
  - Study on State-of-Art co-registration techniques
  - Development of an improved unsupervised deep learning approach, exploiting attention mechanisms (Work in Progress)
  - Development of a new loss function, more precise for the spectral component and more computationally effective (Work in Progress)
  - Development of a sub-pixel co-registration module (Work in Progress)
  - Testing of these solutions on several satellites, such as WorldView-2, WorldView-3, GeoEye-1
- Single Image Super-Resolution:
  - Development of an adversarial training framework for Sentinel-2 Single Image Super-Resolution
  - Development of an unsupervised deep learning approach (Work in Progress)
  - Testing of these solutions on Sentinel-2 satellites

PAN



MS (RYB)



W/o Coreg.



With Coreg.



Residual - w/o Coreg.



Residual - with Coreg.



# Intended Contributions

- Solving the misalignment problem, developing an ad-hoc algorithm based on data
- Analyse and try to solve the problem of moving objects affecting several commercial satellites, such as WorldView-2, WorldView-3, GeoEye-1, etc.
- Passing from Single Image Super Resolution to a Time Series Super-Resolution (Period abroad)
- Attempts to improve the actual algorithm, exploiting new deep-learning trends, such as GAN, Perceptual loss, self-attention mechanism, etc.

# Products

[J1]	M. Ciotola, S. Vitale, A. Mazza, G. Poggi and G. Scarpa, "Pansharpening by Convolutional Neural Networks in the Full Resolution Framework," in <b>IEEE Transactions on Geoscience and Remote Sensing</b> , vol. 60, pp. 1-17, 2022, Art no. 5408717, doi: 10.1109/TGRS.2022.3163887.
[J2]	G. Scarpa, M. Ciotola – "Full-resolution quality assessment for pansharpening", in <b>MDPI Remote Sensing</b> , vol. 14 pp. 1-25, 2022, Art. no. 1808, doi: 10.3390/rs14081808
[C1]	M. Ciotola, A. Martinelli, A. Mazza and G. Scarpa, "An Adversarial Training Framework for Sentinel-2 Image Super-Resolution," <b>IEEE International Geoscience and Remote Sensing Symposium (IGARSS)</b> 2022, pp. 3782-3785, doi: 10.1109/IGARSS46834.2022.9883144.

Thank you for your attention!